Moduliavimas amplitudės ir fazės THz spektrų su 2D plazmonais AlGaN/GaN heterostruktūrose veikiamose nuolatine įtampa

Amplitude and Phase THz Spectra Modulation by 2D Plasmons in AlGaN/GaN Heterostructures under Applied dc Bias

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It is assumed that complementary to graphene, the nitride semiconductors possess unrevealed potential in the THz range suitable for the development of room-temperature plasmonic devices. [1], [2]. Resonant excitation of two-dimensional (2D) plasmons in AlGaN/GaN high electron mobility transistor (HEMT) structures were observed from cryogenic up to room temperatures [3]. Plasmon resonant frequency was found to be proportional to the square root of electron density which is controlled in such devices by external DC voltage applied to gate electrodes [4].

In this work, we investigated modulation of amplitude and phase spectra of 2D plasmons in AlGaN/GaN HEMT structures under DC voltage applied either between gate electrodes (G) and source (S) or between drain (D) and S terminals of grating-coupled plasmonic sample. Time-domain spectroscopy (TDS) system was used to measure THz pulse transmission through the sample at liquid nitrogen temperature. Grating electrodes were fabricated by using e-beam lithography, making a periodic pattern over an area of 2x2mm^2. Grating electrodes with 560 nm width and 1020 nm periodicity were sufficient for resonant 2D plasmon excitation at frequency of 1.5 THz [5]. Ohmic contacts to 2D electron gas (2DEG) channel laying under grating were also processed to implement HEMT configuration.

First, THz spectra were measured by applying external DC voltage between G and S/D terminals (both S and D were shortcut). Spectra of amplitude and phase signals are shown in Fig. 1 (a) and (b), respectively. At zero bias, 2D plasmon resonance was at around 1.5 THz frequency, demonstrating peak amplitude of up to 15% and change of phase as large as 10 degrees. When negative or positive voltage of 1V was applied to the G terminal, the 2D plasmon resonance experienced peak shift to 1.33 THz or 1.63 THz frequencies. It is worth to note that amplitude of peak and phase modulation do not change with applied DC voltage. Such large (0.3 THz) peak position modulation was attributed to 50% change of 2DEG density under gate electrodes. Moreover, the modulation of transmission amplitude and phase spectra by applied voltage was also observed in the spectrum ranging below 0.8 THz, which could be modeled by Drude conductivity[6].

Very similar trend of the position shift of 2D plasmon resonance as well as change of Drude conductivity slope was found biasing the plasmonic sample via S and D terminals, without usage of G terminals. Short-pulse-characterization of plasmonic sample revealed a capacitive-coupling between G and S and D terminals resulting in additional density modulation of gated 2DEG channel in nanosecond time scale. The modulation amplitude was found to be smaller than that for a case of G to S/D biasing, due to number of reasons: (i) charge accumulation on G electrodes, (ii) sufficient leakage currents, (iii) non-uniform internal field distribution.

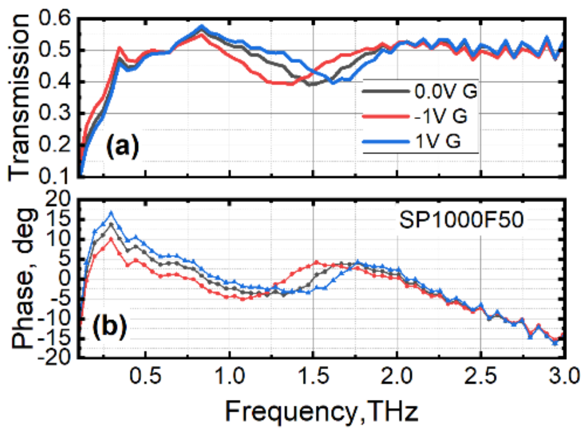

Figure 1. Measured spectra of power (b) and phase (c) transmission through plasmonic AlGaN/GaN structures with grating gate coupler dc-biased at different voltage.

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Key words: 2D plasmons, THz TDS, amplitude and phase spectra modulation, AlGaN/GaN heterostructures.

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